

# PATENT ABSTRACTS OF JAPAN

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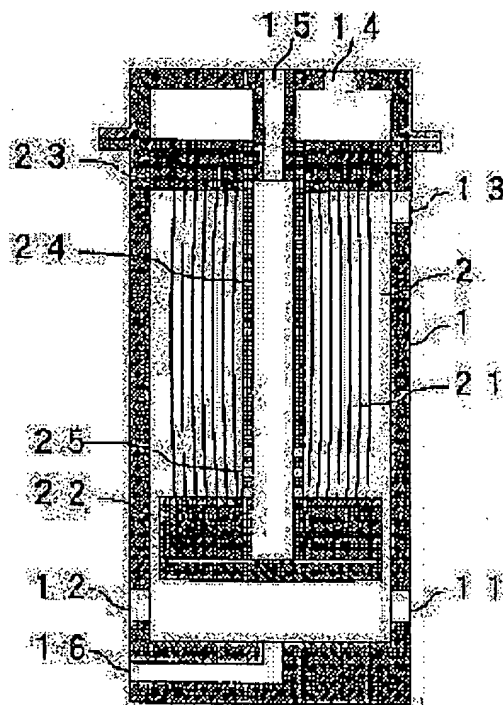
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## (54) HOLLOW FIBER FILTER MEMBRANE ELEMENT AND MODULE

### (57)Abstract:

PURPOSE: To enhance the recovery of filtering capacity due to air scrubbing to a large extent and to also enhance maintenance properties, in a hollow fiber membrane element wherein an air introducing pipe is formed at the central part of hollow fiber membrane bundles, by forming introduced air jet orifices from the outside of the element to the lower part below the half of the total length of the element of the pipe.

CONSTITUTION: In a hollow fiber membrane filter element 2 composed of an external pressure system passing raw water through hollow fiber membrane bundles 21 from the outside of hollow fiber membranes to the inside thereof to filter the same to take out transmitted water from the single ends of the hollow fiber membrane bundles 2 and having an air introducing pipe formed at the central part of the hollow fiber membrane bundles 21 thereof, introduced air jet orifices 25 from the outside of the element are formed to the lower part below the half of the total length of the element of the pipe. As a result, in the hollow fiber membrane filter element filtering a liquid containing fine particles or a suspended substance and a module, the recovery of filtering capacity due to air scrubbing is enhanced to a large extent. Especially, the effect at a time when air jet orifices are arranged in the hollow fiber membrane bundles by an air dispersing pipe or plate is large.



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Maintenance properties are also enhanced.

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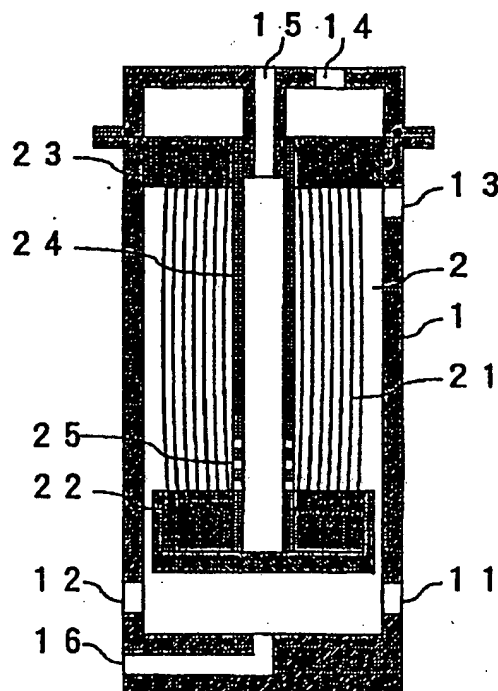
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(54) 【発明の名称】 中空糸濾過膜エレメントおよびモジュール

(57) 【要約】

【目的】 微粒子や懸濁物質を含んだ液体を濾過する中空糸濾過膜エレメントにおいて、エアースクラビングによる濾過性能回復が大幅に向上し、かつメンテナンス性も向上した中空糸濾過膜エレメントおよびモジュールを提供する。

【構成】 原水を中空糸膜束の外側から中空糸内部に濾過する外圧型かつ透過水を片端から取り出す方式であって、該中空糸膜束の中央部にエア導入パイプを有している中空糸膜エレメントであり、かつエレメント全長の1/2より下方にエレメント外部からの導入エア噴出口を持っていることを特徴とする中空糸濾過膜エレメント



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## 【特許請求の範囲】

【請求項1】 原水を中空糸膜束の外側から中空糸内部に濾過する外圧型かつ透過水を片端から取り出す方式であって、該中空糸膜束の中央部にエアー導入パイプを有している中空糸膜エレメントであり、かつエレメント全長の1/2より下方にエレメント外部からの導入エアー噴出口を持っていることを特徴とする中空糸濾過膜エレメント。

【請求項2】 エアー噴出口が、エアー導入用パイプ下部表面に設けられた穴であることを特徴とする請求項1記載の中空糸濾過膜エレメント。

【請求項3】 エアー噴出口が、エアー導入パイプと実質上垂直に連結されたエアー分散板上またはエアー分散管上に設けられていることを特徴とする請求項1記載の中空糸濾過膜エレメント。

【請求項4】 下部端板にエアー噴出手段を備え、該エアー噴出手段がエアー導入パイプに気密に接続されていることを特徴とする請求項1記載の中空糸濾過膜エレメント。

【請求項5】 請求項1記載のエレメントが、原水口、エアー抜き口、排水口、透過水口、エアー導入口を持つモジュール容器に、シール材を介して該容器中に組み込まれていることを特徴とする中空糸濾過膜モジュール。

【請求項6】 モジュール容器下部にエアー噴出口が設けられており、エアースクラビング洗浄時にエレメント及びモジュール容器下部の両方からスクラビングエアーを噴出させることができることを特徴とする請求項5記載の中空糸濾過膜モジュール。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】 本発明は液体の濾過操作を行うための中空糸濾過膜エレメントおよびモジュールに関する。

## 【0002】

【従来の技術】 一般の工業用水中には、多くのSS成分、微粒子、ゴミ、細菌類、藻類、などが含まれており、このまま使用されると、用水配管の目詰まり、細菌の増殖、ライン中のスケール堆積などのトラブルを生じる原因となりやすい。従来、これらの水中混入成分を除去するために、砂濾過、凝集濾過、凝集沈澱処理、カートリッジフィルター濾過などの各種の方法が用途に応じて使用されてきた。これらの一般濾過法にかわる新規な手法として、最近では多孔質の中空糸膜による濾過が実用化されつつある。中空糸膜による水処理、濾過は近年急速に普及し、その適用分野も年々広くなりつつある。

【0003】 中空糸膜の濾過において、中空糸膜は何千〜何万本をひと束に束ねた後に端部を接着剤で固定した形状の、中空糸膜エレメントに加工される。そして、これらのエレメントをモジュール容器に収め、商品形態に加工されたものは中空糸濾過膜モジュールまたは単にモ

ジュールと呼ばれている。液体の濾過が可能な中空糸濾過膜モジュールとしては従来から多くの形態のものが提案されている。特に初期のものとしては、適度な前処置手段と組み合わせて使用される濾過モジュール、逆浸透濾過を目的とし7もの、透析用途を目的としたものなどがあり、これらの用途を主目的として、多くのモジュール形態が提案されており、その主なものを挙げると、特公昭48-28380号公報、特開昭49-68550号公報、特開昭53-100176号公報、などに記載されているものがある。これらは、全て、使い捨て、あるいは汚れが一定量以上付着した段階において、清澄水または薬液水による洗浄やフラッシング処理を実施するのが普通であった。

【0004】 これに対して、最近では、中空糸濾過膜モジュール形状に工夫を凝らし、エアーにより中空糸膜面の付着物を定期的に脱落させて中空糸膜の性能回復を実施する方法が試みられている。特開昭61-263605号公報は、中空糸膜をU字型に組み込み、容器に収納して使用するものであり、定期的に容器の下部に設けられたエアー導入口からエアーを導入させてエアースクラビングにより中空糸膜を振動させ、膜面の堆積物の除去を試みるものである。また、特開昭60-206415号公報は、中空糸膜を中心パイプの回りに配列させた両端固定型モジュールであり、前記同様に容器に組み込み、エアースクラビングにより中空糸膜面の堆積物を除去するものである。これらの技術は、既に実用化の検討が開始されている。

【0005】 また、特開昭48-34763号公報では圧縮空気膜に付着した微粒子を剥離させ次いで濾液または他の液で逆洗する方法も示されている。

## 【0006】

【発明が解決しようとする課題】 中空糸濾過膜モジュールによる水処理において、中空糸膜表面の堆積物をエアースクラビングや逆洗により除去するのは良い方法であり、このような方法により膜表面の堆積物を除去（洗浄）することにより、濾過前の状態にほぼ回復でき、濾過性能もほぼ回復し、中空糸濾過膜モジュールの寿命が伸び経済的である。しかしながら従来のエアースクラビングでは、エアーをモジュール容器下部からのみ噴出する形式がほとんどで、この方法では特に中空糸束の径が大きくなった場合には、気泡が中空糸束の内部まで入らず、中空糸束の表層付近の堆積物を除去するにどまっていた。エアーをモジュール容器下部以外から噴出させる例としては実開平3-15627の様に、全長にわたって多数の穴が開いた穴開き空気圧送管を用いる方法も考案されている。しかしながら、特にモジュールの全長が長くなり、モジュール上部と下部の水圧の差が大きい場合においては、空気が穴開き空気圧送管の上部の穴から、モジュール上部の空気が溜まっている部分に噴出するだけで洗浄に重要な気泡をほとんど発生させることが

**[0007]**

【0011】中空糸膜エレメントは、中空糸束21の片端または両端部が接着剤により固定されている。図1は両端部を固定した中空糸膜エレメントの例であるが、下部端板22、上部端板23があり、その片方の端板で中

【0019】ここで用いられる中空糸濾過膜エレメントは、原水を中空糸膜の表面に無数にあいている微細孔で濾過し、SS成分や微粒子、ゴミ、細菌などが除かれた清澄水だけが中空糸膜内部に透過し、濾過水出口から濾過水として取り出される。中空糸膜エレメントにはこのように精密濾過、限外濾過を行う用途から中空糸膜を通して物質を透析、逆浸透を行う用途、また液体間の物質移動にとどまらず液体と気体間で物質移動を行う用途、50 気体間で物質移動を行う用途までその種類・用途は多岐

にわたっている。通常中空糸濾過膜エレメントの濾過においては原水圧力が大きいほど濾過水量は大きくなるが、濾過時間の経過と共に前記SS成分、微粒子などが膜面に付着して多かれ少なかれ中空糸膜の目詰まりが生じ、同一圧力あたりの濾過水量が徐々に低下していくのが普通である。よって、中空糸膜の目詰まりが進行して濾過水量が低下した適当な時点において、逆洗やエアースクラビングを始めとする洗浄操作を行い、目詰まり前に近いレベルにまで中空糸膜の濾過水量を回復させることが必要となってくる。

【0020】中空糸濾過膜エレメントを組み込んだモジュールの使用法としては限定されず、使用者の希望に合わせて設定することができる。運転方法の例としては、圧力を一定として濾過水量を変化させる運転方法、圧力を自動または手動でコントロールしながら濾過水量を一定に保ち運転する方法、適当な原水源にモジュールを接続して、圧力温度共に成り行きのままに運転する方法などが挙げられる。

【0021】本発明者らは、この中空糸濾過膜エレメントの洗浄において、エアースクラビングによる膜洗浄効率の向上、およびモジュールメンテナンス性を向上させる方法について鋭意検討を行った結果、本発明を見いだした。

【0022】本発明の中空糸濾過膜エレメントおよびモジュールは、多孔質中空糸膜の束を濾過材として使用した濾過用素子であれば、形式は問わない。好ましい中空糸濾過膜エレメントの形状については、多数の中空糸膜の束の両端を接着剤でシールした後に、この接着シール部の片端を切断することにより中空糸膜を開孔させた構造であり、エレメント組み込み式としてモジュール容器内部に収納されているのが普通である。組み込み方法としてはエレメントと容器はシール材を介して組み込まれ、任意にエレメントを容器内から取り外せる容器組み込み型が好ましいが、接着材などによりエレメントと容器が一体に接着されている構造を採用することもできる。

【0023】本発明に使用する中空糸濾過膜エレメントを構成する中空糸膜素材としては、多孔質の中空糸膜であれば特に限定しないが、ポリエチレン、ポリプロピレン、ポリスルホン、ポリエーテルスルホン、ポリビニルアルコール、セルロースアセテート、ポリアクリロニトリル、その他の材質を選択することができる。この中で特に好ましい中空糸膜素材としては、エアースクラビングに対して十分な機械的強度を有しているという面から、アクリロニトリルを少なくとも一成分とする重合体からなる中空糸膜が適当である。アクリロニトリル系重合体の中でも最も好ましいものとしては、アクリロニトリルを少なくとも50モル%以上、好ましくは60モル%以上と該アクリロニトリルに対して共重合性を有するビニル化合物一種または二種以上を50%以下、好まし

くは0~40モル%からなるアクリロニトリル系重合体である。また、これらアクリロニトリル系重合体二種以上、さらに他の重合体との混合物でも良い。上記ビニル化合物としては、アクリロニトリルに対して共重合性を有する公知の化合物であれば良く、特に限定されないが、好ましい共重合体成分としては、アクリル酸、イタコン酸、アクリル酸メチル、メタクリル酸メチル、酢酸ビニル、アリルスルホン酸ソーダー、p-スチレンスルホン酸ソーダー等を例示することができる。

10 【0024】また、次に好ましい中空糸素材としては、エチレンプロピレンまたは4メチルペンテンなどの単独または二種以上のオレフィン系重合体からなり、中空糸膜形状として表面に長径0.1~10μm、短径0.01~1.0μmのスリット状の細孔を有するものが適当である。

【0025】

【実施例】

実施例1

20 本発明の中空糸膜エレメントとして、外径470μm、内径350μm、平均ポアサイズ0.01μmのポリアクリロニトリル多孔質中空糸膜20,000本からなる中空糸膜の両端部をエアー噴出口を持つエアー導入パイプとともにウレタン接着剤で固定し、しかる後に接着剤固定部の片端を切断することにより中空糸膜を開孔させたものを製作した。このエレメントを、直径17cm長さ120cmのモジュール容器に収めた中空糸濾過膜モジュールを用いて濾過実験を行った。

30 【0026】濾過実験では湖水にポリ塩化アルミニウム(PAC)を5ppm添加した原水を用い、濾過処理における流量は圧力の自動調整により8リットル/分になるように調整した。エレメントの目詰まりが生じても圧力が程度に応じて上昇し所定の流量が維持されるようになっている。また、供給圧力が1.0kgf/cm<sup>2</sup>に到達した時点で透過水による逆洗とエアー導入パイプおよびモジュール下部からのエアースクラビング洗浄を行い、排水した後に通常運転に戻るというサイクルを繰り返した。この実験では1000時間を経過しても順調に濾過でき中空糸束内部や中空糸束の下部端板付近も堆積物で中空糸が固着することはなかった。

40 【0027】実施例2

エアー噴出孔が、図2、図3のようにエアー導入パイプと垂直に連結されたエアー分散管上に設けられている中空糸膜エレメントを使用したこと以外は、実施例1と同様の実験を行なった。この実験では実施例1の時と同様に1000時間を経過しても順調に濾過でき、下部端板付近の中空糸束束への汚れの堆積がエアー分散管の効果のによって実施例1より少なかった。

【0028】比較例1

50 中空糸濾過膜エレメントおよび原水、運転条件は実施例1と同様にし、エアースクラビング時に従来型のエレメン

トと同様にモジュール下部からのみエアーを供給し、エレメントのエアー噴出口からはエアーを供給しなかった。実験開始後1000時間を経過した時点で、中空糸膜束内部、特に下部端板付近で堆積物により中空糸束が固着し、有効膜面積が減少していることがわかった。

【0029】

【発明の効果】本発明により、微粒子や懸濁物質を含んだ液体を濾過する中空糸濾過膜エレメントおよびモジュールにおいてエアースクラビングによる濾過性能回復が大幅に向上する。特にエアー噴出口をエアー分散管、エアー分散板などで中空糸膜束の中に配した時の効果が大きい。またメンテナンス性が向上した中空糸濾過膜エレメントおよびモジュールが提供される。

【図面の簡単な説明】

【図1】 本発明エレメントエアー導入パイプ、エアー噴出手段を備えた中空糸濾過膜エレメントが、モジュール容器に組み込まれたモジュールの一例の縦断面図である。

【図2】 本発明のエアー分散管を備えた中空糸濾過膜エレメントが、モジュール容器に組み込まれたモジュールの一例の横断面図である。

【図3】 本発明のエアー分散管を備えた中空糸濾過膜エレメントが、モジュール容器に組み込まれたモジュールの一例のエアー噴出口付近の縦断面図である。

【図4】 本発明の下部端板にエアー噴出手段を備えた中空糸濾過膜エレメントが、モジュール容器に組み込まれたモジュールの一例の横断面図である。

【図5】 本発明の下部端板にエアー噴出手段を備えた中空糸濾過膜エレメントが、モジュール容器に組み込ま\*

＊れたモジュールの一例のエアー噴出口付近の縦断面図である。

【図6】 本発明のエアー分散板を備えた中空糸濾過膜エレメントが、モジュール容器に組み込まれたモジュールの一例の横断面図である。

【図7】 本発明のエアー分散板を備えた中空糸濾過膜エレメントが、モジュール容器に組み込まれたモジュールの一例のエアー噴出口付近の縦断面図である。

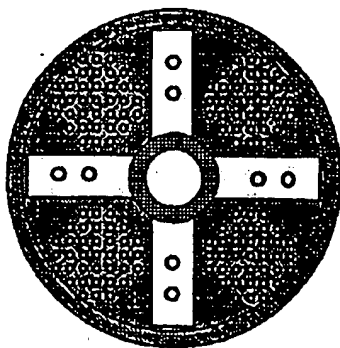
【図8】 本発明のモジュール容器下部にエアー噴出手段を備えた中空糸濾過膜モジュールの一例の縦断面図である。

【図9】 中空糸膜をU字型にしたエレメントがモジュール容器に組み込まれたモジュールに本発明を適用した一例の縦断面図である。

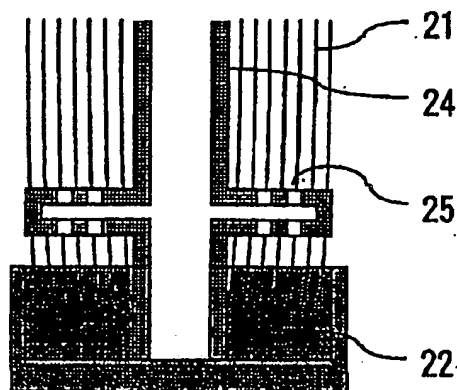
【符号の説明】

- 1：モジュール容器
- 2：中空糸膜エレメント
- 11：原水供給口
- 12：排水口
- 13：エアー抜き口
- 14：透過水口
- 15：エアー導入口
- 16：モジュール下部エアー導入口
- 21：中空糸膜束
- 22：下部端板
- 23：上部端板
- 24：エアー導入パイプ
- 25：エアー噴出口

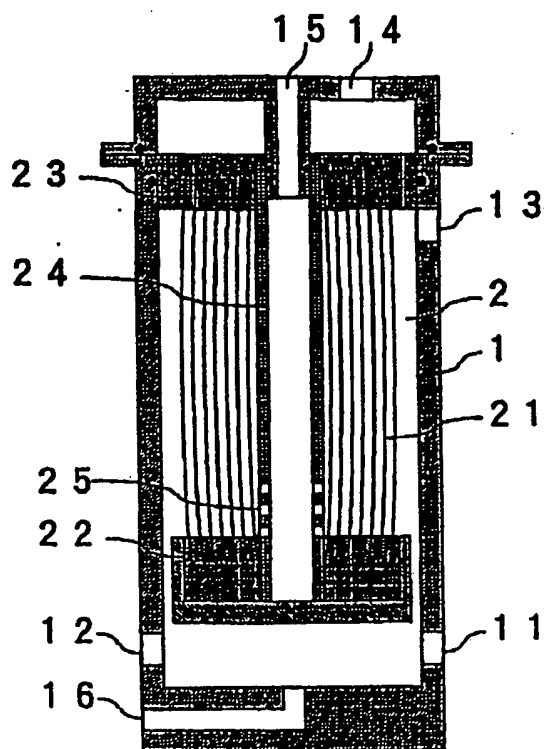
【図2】



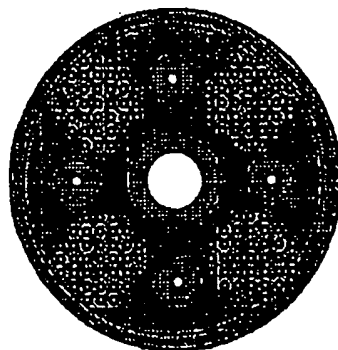
【図3】



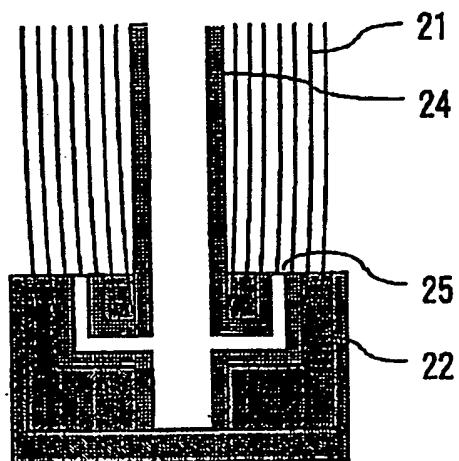
【図1】



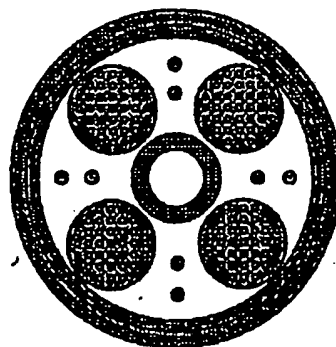
【図4】



【図5】

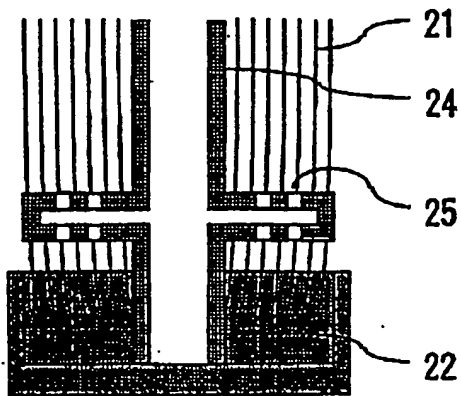


【図6】

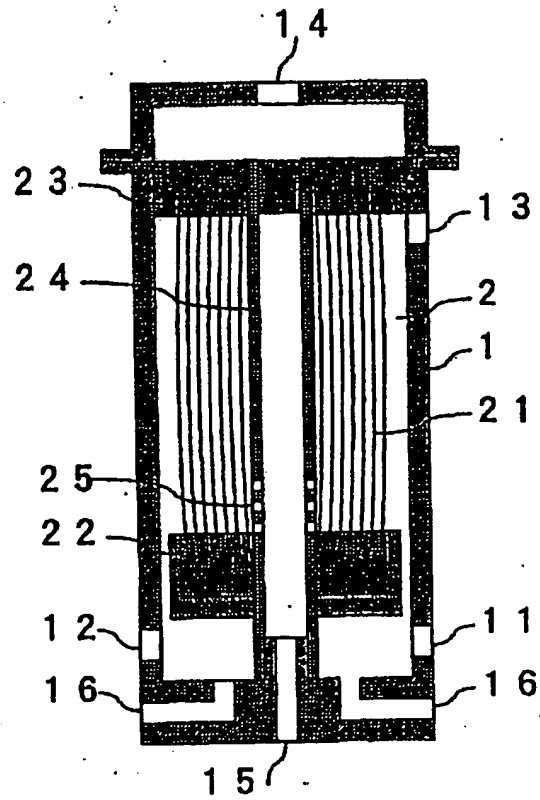




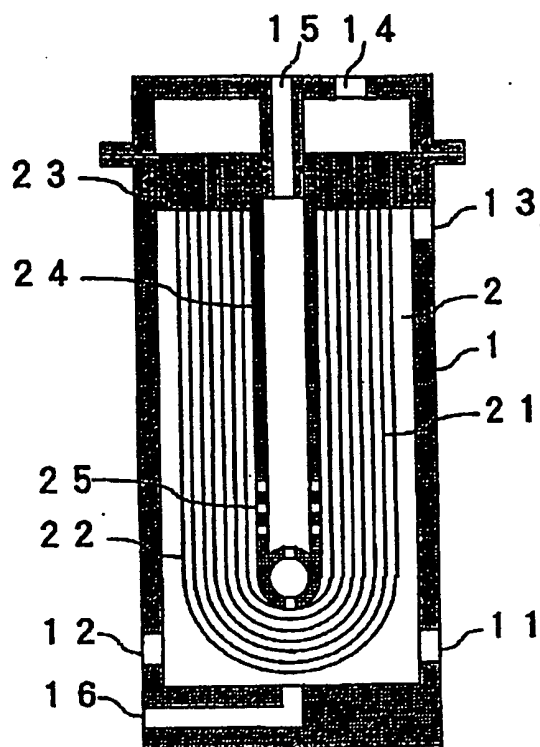
【図7】

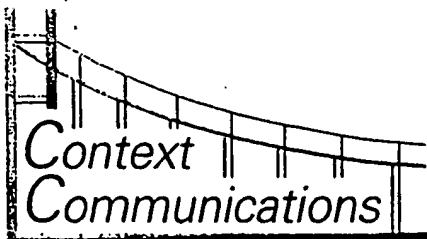


【図8】



【図9】





## Certification

I, Alex Kent, a professional translator, hereby certify that the attached English document,  
Publication of an Unexamined Patent Application 07-185268, is a true and faithful translation  
from the Japanese language.

By Alex Kent Sept 1, 2004

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**(54) Title of Invention: HOLLOW FIBER FILTER MEMBRANE ELEMENT AND MODULE**

**(57) Abstract**

**Purpose**

To provide a hollow fiber filter membrane element and module with a marked increase in the recovery of filtering capacity and enhanced maintenance properties in a hollow fiber filter membrane element that filters liquids containing fine particles

and suspended materials.

**Constitution**

A hollow fiber filter membrane element comprising an external pressure system that passes raw water from the outside through hollow fiber membrane bundles to the inside thereof to filter the same and remove the processed water from one end, an air

inlet pipe in the central part of the hollow fiber membrane bundles, and in which there are inlet air jet orifices from the outside formed in the lower half of the total length of the element.

#### **Claims**

##### **Claim 1**

A hollow fiber filter membrane element comprising an external pressure system that passes raw water from the outside through hollow fiber membrane bundles to the inside thereof to filter the same and remove the processed water from one end, an air inlet pipe in the central part of the hollow fiber membrane bundles, and in which there are inlet air jet orifices from the outside formed in the lower half of the total length of the element.

##### **Claim 2**

The hollow fiber filter membrane element recited in Claim 1 wherein the air jet orifices are holes provided in the lower surface of the air inlet pipes.

##### **Claim 3**

The hollow fiber filter membrane element recited in Claim 1 wherein the air jet orifices are provided in the air diffuser plate or air diffuser tube that connects effectively perpendicularly with the air inlet pipe.

##### **Claim 4**

The hollow fiber filter membrane element recited in Claim 1 wherein an air jet means is provided in the lower end plate, and in which there is an air-tight connection between this air jet means and the air inlet pipe.

##### **Claim 5**

A hollow fiber filter membrane module in which the element recited in Claim 1 is fitted into a module container provided with a raw water orifice, an air relief orifice, a drain orifice, a filtered water orifice, and an air inlet, with sealing material inter-

posed with this container.

##### **Claim 6**

The hollow fiber filter membrane module recited in Claim 5 is provided with an air jet orifice at the bottom of the module container to enable scrubbing air to be introduced into both the element and the bottom of the module container when cleaning by air scrubbing.

0001

#### **Industrial Field of Use**

This invention relates to hollow fiber filter membrane elements and modules used for filtering operations.

0002

#### **Prior Art**

There are typically large quantities of SS<sup>1</sup>, fine particles, dirt, microorganisms, algae, etc. in industrial water. Continued use of such water can result in clogged pipes, bacterial propagation, buildup of scale in lines, and other problems. Typically, a variety of methods, including sand filtration, condensation filtration, cartridge filtration, and others have been used to remove these materials from the water. A new method that has recently been used in place of these filtration methods has been the application of porous hollow fiber membranes. In recent years, there has been a rapid increase in the use of hollow fiber membranes for water treatment and filtration, and the areas in which this technology is applied are growing from year to year.

0003

In filtration with hollow fiber membranes, several thousand to several tens of thousands of hollow fiber membranes are bundled into a single bundle, and their ends are in some way fixed using adhesive

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<sup>1</sup> Translator's note: SS = semisolids

in order to form a hollow fiber membrane element. These elements are then housed in a module container. Hollow fiber filtration membrane modules that are manufactured into the form of products are simply called "modules". A wide variety of forms have been proposed as hollow fiber filtration membrane modules that can filter liquids. In particular, filtration modules were initially proposed for use in combination with appropriate pre-treatment methods for purposes of reverse osmosis filtration, for dialysis applications, and so on. A wide variety of modules have been proposed for these various applications, and some of the principal examples are found cited in Patent Publications 48-28380 and Unexamined Patent Publications 49-69550, 53-100176, etc. These are all either disposable or embodiments which use chemically-treated water in order to clean or flush [the filters] after a certain amount of dirt builds up in them.

0004

On the other hand, there have been recent tests in which ways have been developed to shape a hollow fiber filtration membrane module and to periodically remove material adhering to the surface of the hollow fiber membrane with air, thereby recovering the functionality of the hollow fiber membrane. In Unexamined Patent Publication 61-263605, the hollow fiber membranes are formed into a U-shape and housed within a container. Air is periodically introduced into the bottom of the container through an air inlet orifice provided therein in order to perform air scrubbing which vibrates the hollow fiber membrane, thereby removing accumulations' on the membrane surface. Also, Unexamined Patent Publication 60-206415 discloses a module in which hollow fiber membranes are disposed around a central pipe which is then fitted into a container having a U-shape, as above, and wherein material that has

built up upon the hollow fiber membrane surfaces is removed by means of air scrubbing. Studies are already under way toward the reduction of these technologies to practice.

0005

Furthermore, Unexamined Patent Publication 48-34763 discloses a method in which fine particles adhering to the membrane are peeled off with compressed air and backwashed with the filter liquid or with another liquid.

0006

#### **Problems the Invention is Intended to Resolve**

Air scrubbing and backwashing are good methods for the removal of accumulations on the hollow fiber membrane surfaces resultant from the processing of water with hollow fiber filter membrane modules, and it is possible to restore the filter more or less to its condition prior to filtration by removing (washing) the membrane surfaces with methods such as these, thereby recovering filter functionality and extending the service life of hollow fiber filter membrane modules in an economical fashion. However, most prior art air scrubbing methods involve the use of air jets only from the bottom of the module, and particularly in the case of large hollow fiber bundles, these methods do not allow the bubbles to get into the interior of the hollow fiber bundles, and only remove accumulated material near the surface of the hollow fiber bubbles. Methods have been proposed in which multiple holes are provided over the entire length [of the container] and use an air pressure line as in the case of Utility Model 3-15627, wherein air is introduced into the module container from locations other than the bottom of the container. Nevertheless, this method is defective because if the overall length of the module is long and there is a significant difference in water pressure between the top and bottom portions of the

module, it is virtually impossible to generate enough of the bubbles that are critical for washing because air tends to pool at the top of the module and be introduced into the module from the air holes and air pressure supply line holes near the top. Further, accumulated material that has been cleaned tends to build up in the vicinity of the air jet orifice at the bottom of the module container, causing clogging of the air jet orifices, and making it harder to clean the hollow fiber membranes. Therefore, there is a need for a module in which the entire hollow fiber membrane bundles in the elements can be cleaned and in which there is little clogging of the air jet orifices.

0007

#### Means of Solving the Problems

The goals of this invention are essentially achieved in a hollow fiber filter membrane element comprising an external pressure system that passes raw water from the outside through hollow fiber membrane bundles to the inside thereof to filter the same and remove the processed water from one end, an air inlet pipe in the central part of the hollow fiber membrane bundles, and wherein inlet air jet orifices from the outside are formed in the lower half of the total length of the element.

0008

In the hollow fiber filter membrane element and module of this invention, inasmuch as the single air scrubbing air jet orifice for the physical cleaning of the hollow fiber filter membrane element is provided within the fiber bundle, the membrane is effectively shaken inside of the fiber bundle resulting in a significant increase in the recovery of filter performance due to air scrubbing compared with prior art elements in which air scrubbing is done from the lower part of the element. Moreover, since the air jet orifice is provided inside an element that is periodically replaced, such problems as clogging of the air jet ori-

fices can basically be handled by periodic replacement of the element, thereby contributing to improved maintenance characteristics of membrane treatment devices.

0009

The following detailed description of the invention is based on the drawings, but this invention is not limited to the drawings.

0010

Figure 1 shows an example of an element of this invention in which an air inlet orifice is provided near the lower end plate of the air inlet pipe provided in the center, and which is fitted into a module container. A module container lower air jet orifice as recited in Claim 5 is also provided at the bottom of the module container. The module container 1 cap can be removed to facilitate easy replacement of the element, and the element is installed in the container with sealing materials interposed. Moreover, the module container is provided with a raw water supply inlet 11 that supplies raw water, a drain orifice 12 that drains liquid in the module container, an air relief orifice 13, a processed water orifice 14, an air inlet orifice 15 that connects with the element air inlet pipe, and a module container lower air inlet orifice 16 that can be used in combination for air scrubbing from the lower portion of the module container. Furthermore, a hollow fiber membrane element is housed within the module container.

0011

The hollow fiber membrane element is fixed in place on one end or both ends by adhesive. Figure 1 is an example of a hollow fiber membrane element that is fixed on both ends, and it has a lower end plate 22, upper end plate 23, and there are openings in one end plate for the hollow fibers, so that processed water can be removed. In the example shown in Figure 1, the hollow fiber membrane is open at the

upper end plate. Also, the top and the lower end plates are connected by an air inlet pipe 24, and the air inlet pipe is connected in an airtight way with the module container air inlet orifice.

0012

The example shown in Figure 1 has holes provided at the bottom of the air inlet pipe 24 that serve as air jet orifices 25, but slits may be used in place of the hole-shaped air jet orifices shown in Figure 1.

0013

Further, as shown in Figures 2 and 3, it is acceptable to provide air diffuser tubes that branch off from the air inlet pipe. Although the air diffuser tube effectively connects with the air inlet pipe perpendicularly, it may be connected within a range of angles off the perpendicular as long as this does not interfere with the effect of the invention. Also, it is preferable that the location of connection be below  $1/4$  the overall length of the element.

0014

While there are no particular limitations on the number and length of air diffuser tubes, there should be at least 2, preferably at least 3, and even more preferably 4 or more. If the hollow fiber membranes are divided into a number of membrane bundles, then the number should preferably be the same as the number of hollow fiber membrane bundles, or a multiple of the integers. With regard to length, they should preferably be more than  $1/2$  the radius of the element. The air jet orifice should preferably be about  $1/2$  the radius of the element.

0015

Otherwise, it is acceptable to configure [the air diffuser pipe] inside the lower end plate as shown in Figures 4 and 5, but these may also be provided in the air diffuser plate installed within the air inlet pipe, as shown in Figures 6 and 7. What is here called an air diffuser plate is something having an external

shape that is the same as the bundling plate that bundles the hollow fiber membrane bundles. They have air jet orifices in their surface, and are structured so that the air that has been conducted from the air inlet pipe is ejected.

0016

These are examples of forms of [the invention], and the invention is not necessarily limited to these. In Figures, 2, 3, 4, and 5, the air jet orifices are located in between the hollow fiber membrane bundles where there are no hollow fibers, but there is no impediment to providing the air jet orifices near the inside of the hollow fiber membrane bundles.

0017

Figure 8 shows an example in which the air inlet orifices are located at the bottom of the module container, and the air inlet pipes are connected in an airtight way to the air inlet orifices at the bottom of the module container. Otherwise, it is the same as the example shown in Figure 1.

0018

Figure 9 shows an example of an application of the invention in which the hollow fiber membranes are formed into a U-shape to form an element with a take-off at one end.

0019

The hollow fiber filter membrane elements used here filter raw water through countless minute holes in the surface of the hollow fiber membrane, passing only pure water from which SS and fine particle components, debris, microorganisms, and so on have been removed, to the inside of the hollow fiber membrane, and filtered water is drawn off from the filtered water orifice. Hollow fiber membrane elements span a wide range of varieties and applications, including not only this sort of precision filtration or ultra-filtration, in which the hollow fiber membranes perform dialysis, reverse osmosis or materials trans-



fer between liquids, but also applications in materials transfer between liquids and gases, or for materials transfer between gases. Although it is common in filtration using hollow fiber membrane elements that the larger the volume of raw water filtered, the larger the volume of filtrate, as the filter is used over time, it is typical for the SS components, fine particles, etc. to build up on the membrane surface, more or less clogging the hollow fiber membrane mesh, and gradually reducing the amount of filtered water per unit of pressure. Thus, as clogging progresses, and when the reduction in the amount of filtered water reaches a certain point, cleaning operations are performed using backwashing or air scrubbing in order to recover the amount of filtered water nearly to levels before the clogging occurred.

0020

The ways in which modules into which hollow fiber filter membrane elements that have been fitted into modules can be used may be determined according to the needs of users, and there are no limitations on the ways in which they may be used. Some of the ways in which they may be operated include operation methods in which the amount of filtered water is varied at constant pressure, operation in which the amount of filtered water is kept constant while automatically or manually controlling pressure, or methods in which the module is attached to an appropriate raw water source and run at whatever the pressure and temperature happens to be.

0021

This invention is the result of thorough investigations conducted by the inventors into ways to improve the effectiveness of air scrubbing in the cleaning of hollow fiber filter membrane elements and into improvements in their maintenance properties in the cleaning of hollow fiber filter membrane elements.

0022

The form does not matter if the hollow fiber filter membrane element and module of this invention is a filter element using porous hollow fiber membrane bundles as its filter material. Preferred forms for the hollow fiber filter membrane element of this invention are structures in which holes are formed in the hollow fiber membrane by cutting one end of the adhesive seal area after both ends of the hollow fiber filter membrane bundle are sealed with adhesive. Also, it is typical for the element to be housed inside a module container. Although it is preferable for the element to be fitted into a module container with a sealing material interposed in between and able to be removed from the container at will, a structure may also be used in which the element is bonded with the container by means of adhesive, etc.

0023

As long as they are porous hollow fiber membranes, there are no particular constraints on the hollow fiber membrane material comprising the hollow fiber filter membrane element of this invention, but polyethylene, polypropylene, polysulfone, polyethylsulfone, polyvinyl alcohol, cellulose acetate, polyacrylonitrile, or other materials may be selected. Among these, as a particularly preferable material for a hollow fiber membrane, polymers containing acrylonitrile as at least one of its components are appropriate, given acrylonitrile's sufficient mechanical strength when subjected to air scrubbing. The most preferable acrylonitrile polymer is a single or two or greater copolymer of over 50 mole% acrylonitrile, and preferably over 60 mole% acrylonitrile versus under 50%, and more preferably 0~40 mole% single or 2 or greater vinyl compounds. Moreover, it is also acceptable for there to be other polymers in addition to these single or 2 or more acrylonitrile polymers. As for the above-mentioned vinyl com-

pounds, well-known compounds which are copolymers having acrylonitrile may acceptably be used and there are no particular limitations, but preferable copolymer compounds such as acrylic acid, itaconic acid, methacrylic acid, methacrylic acid methyl, polyvinyl acetate, allyl sulfonic acid soda, p-styrene sulfonic acid soda, among others can be mentioned.

0024

Further, the following materials are suitable for the hollow fibers: independents such as ethylene-propylene or 4-methyl pentene, or two or more olefinic polymers. A slit-shape long and narrow hole is appropriate for the hollow fiber membranes, with a long surface diameter of  $0.1\mu\text{m}$ ~ $10\mu\text{m}$  and a short diameter of  $0.1$ ~ $1.0\mu\text{m}$ .

0025

#### Embodiments

##### Embodiment 1

The hollow fiber membrane element of this invention has an outer diameter of 470 cm, and an inner diameter of 350 cm, and an average bore size of  $0.01\mu\text{m}$ , consisting of 20,000 strands of polyacrylonitrile porous hollow fiber membrane, having air inlet pipes which have air jet orifices on both ends and which is fixed with urethane adhesive. After fixation [with urethane adhesive], the adhesive fixation parts at both ends are cut to form holes in the hollow fiber membrane. Filtration experiments were conducted with this element installed in a module container having a diameter of 17 cm and a length of 120 cm, forming a hollow fiber filter membrane module.

0026

The filtering experiments used raw water to which 5 ppm of poly aluminum chloride (PAC) were added, and automatic pressure adjustment was used to adjust the flow volume so that it was 8 liters/minute during filter processing. The pressure

rises according to the degree of element clogging to maintain the desired flow volume. When the supply pressure reached  $1.0\text{ kgf/cm}^2$ , back washing was performed using the processed water, and washing by means of air scrubbing was performed by introducing air through the air inlet pipes and from the bottom of the module, and normal operations were resumed after draining water to complete one cycle. Normal filtration was possible even after 1,000 hours had elapsed in these tests, and there was no accumulation of material either on the hollow fiber bundles inside or the lower end plates of the hollow fiber bundles.

0027

##### Embodiment 2

Experiments were performed as in Embodiment 1 with the exception that the hollow fiber membrane element was provided with air diffuser tubes connecting the air jet holes perpendicularly to the air inlet pipe as shown in Figures 2, 3. In these tests, normal filtering could be performed as in Embodiment 1 even after 1,000 hours had elapsed, and as in Embodiment 1, due to the effect of the air diffuser tubes, there was very little buildup of dirt on the hollow fiber membrane bundles in the vicinity of the lower end plate.

0028

##### Comparative Example 1

The hollow fiber filter membrane element and raw water, as well as the operating parameters were identical to those used before the embodiments, and air was supplied from the bottom of the module for air scrubbing in the same way as for prior art elements, and air was not supplied from air jet orifices in the element. After 1,000 hours had elapsed from the start of the experiment, the hollow fiber bundles, particularly in the vicinity of the lower end plate, were caked with accumulated material, and a decline in the usable membrane surface area was observed.

### Effect of the Invention

This invention significantly increases the recovery of filtering capacity by air scrubbing in hollow fiber filter membrane elements and modules that filter liquids containing fine particles and suspended materials. It is particularly effective when air jet orifices are disposed inside the hollow fiber membrane bundles by means of air diffuser tubes, air diffuser plates, and so on. Moreover, a hollow fiber filter membrane element and module are provided having enhanced maintenance properties.

### Brief Description of the Drawings

**Fig. 1** Vertical cross-section of an example of a module into which a hollow fiber filter membrane element of this invention provided with an element air inlet pipe and air jet means are fitted into a module container.

**Fig. 2** A horizontal cross section of an example a module into which a hollow fiber filter membrane element of this invention provided with air diffuser tubes is fitted into a module container

**Fig. 3** A vertical cross-section in the vicinity of the air jet orifices of an example a module with a hollow fiber filter membrane element of this invention provided with air diffuser tubes and fitted into a module container

**Fig. 4** A horizontal cross-section in the vicinity of the air jet orifices of an example of a module into which a hollow fiber filter membrane element of this invention provided with air jet means in the lower end plate and which is fitted into a module container

**Fig. 5** A vertical cross-section in the vicinity of the air jet orifices of an example of a module in which a hollow fiber filter membrane element

of this invention provided with air jet means in the lower end plate and which is fitted into a module container

**Fig. 6** A horizontal cross section of an example of the module in which a hollow fiber filter membrane element of this invention provided with air diffuser plate is fitted into a module container

**Fig. 7** A vertical cross section of an example of the module in which a hollow fiber filter membrane element of this invention provided with air diffuser plate is fitted into a module container

**Fig. 8** A vertical cross-section of an example of a hollow fiber filter membrane module provided with air jet means that the bottom of the module container of this invention

**Fig. 9** A vertical cross-section of an example of this invention which is a module into which a U-shaped hollow fiber membrane element is fitted into the module container

### Symbols

- 1 Module container
- 2 Hollow fiber membrane element
- 11 Raw water supply orifice
- 12 Drain orifice
- 13 Air relief orifice
- 14 Processed water orifice
- 15 Air inlet orifice
- 16 Module lower air inlet orifice
- 21 Hollow fiber membrane bundle
- 22 Lower end plate
- 23 Upper end plate
- 24 Air inlet pipe
- 25 Air jet orifice

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